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ABSTRACT

This paper sought to identify some of the dimensions, correlates, and effective treatments of mathematics anxiety. The introductory section provides a statement of the problem, defines the purpose, organization, and limitation of the study, and includes a glossary of terms. In the second section, an annotated bibliography is presented, organized into three categories: the nature of math anxiety; causes and correlates of math anxiety; and treatments of math anxiety. In the third section, the findings of the literature are summarized. The many correlates of math anxiety are noted, including attitudes, test anxiety, low mathematics self-concept, and sex. The use of behavioral interventions and more academically focused interventions are discussed. Following a brief conclusion, eight recommendations are listed. The appendix provides an annotated list of studies on the validity and reliability of the Mathematics Anxiety Rating Scale. A 47-item bibliography is also included. (MNS).

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THE NATURE AND TREATMENT

OF

MATHEMATICS ANXIETY

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INTRODUCTION

In the midst of a technological age, declining mathematics (math) scores on the Scholastic Aptitude Test (SAT) have been widely publicized, and Goldberg and Harvey (1983, p. 75) have reported that American students ranked last when compared with students from all other industrialized countries on 19 different assessments. In response to this information, Gallup (1983, p. 31) found that the American public rated math first in importance when compared with other academic areas. Educators, parents, politicians and others are trying to assess the cause for this apparent academic weakness, and solutions to the problem are being sought.

In the meantime, students are facing the same problem but from a different perspective: the classroom. When presented with math problems some students find themselves anxious, distracted, and sweaty palmed (Tobias, 1978, p. 44). Math anxiety has been found by Elliott (1983, pp. 778-782) to have physiological as well as psychological bases, and has been found to have many correlates and manifestations (Frary, 1983, p. 993). Clearly, math anxiety is not the sole reason for lowered math achievement in this country, however, it is a critical academic problem and educators should be informed of its nature as well as of its solutions.

STATEMENT OF THE PROBLEM

Researchers have located and hypothesized societal reasons for math anxiety (Fennema and Sherman, 1977, p. 66) as well as effective interventions for alleviating the problem (Genshaft, 1980, p. 95); yet students today are still faced with math anxiety (Dew and others, 1984, p. 582).

PURPOSE OF THE STUDY

The purpose of the study was to identify some of the dimensions, correlates and effective treatments of math anxiety. The perpetual nature of this anxiety and resulting deleterious effects on students' education have been demonstrated (Frary, 1983, p. 993). At the same time, however, researchers and educators have demonstrated the effectiveness of some interventions (Genshaft, 1982, p. 33). Educators need to be aware of the prevalence of the problems and the treatments so that progress can be made.

ORGANIZATION OF THE STUDY

The first part of this study will deal with the nature of math anxiety. Included in this section will be studies that have identified various components of the problem.

The second section will discuss causes and correlates of math anxiety. Factors will be discussed that have been found to co-vary with math anxiety, or to have an effect on the levels of

anxiety experienced by students.

Finally, research on interventions for math anxiety will be covered. Annotations are organized according to the above three categories, and ordered alphabetically by author within those sections.

LIMITATIONS OF THE STUDY

While much has been written on this topic, empirical research was fairly limited. While some researchers established and discussed relationships between some of the correlates of math anxiety (Betz, 1978, p. 441), several of the correlates studied had limited research devoted to them. Specifically, while sex is an important factor mentioned by many authors (Sherman, 1980, p. 476; Fennema and others, 1977, pp. 51-52), a minimum of the research tied together the sex differences, why they exist, and how they should be handled.

GLOSSARY

Anxiety - Anxiety is the "distress of mind, uneasiness" (Webster's Dictionary, 1966, p. 21).

Attribution theory - This theory "deals with the processes by which people attribute actions or attitudes" (Swensen, 1973, p. 267).

Cue-controlled relaxation - This procedure involves "relaxation training and cue-word pairing" (Bander, 1982, p. 98).

Desensitization - This is "a therapy procedure aimed at reducing anxiety in which an individual is exposed to a series of real-life or imagined situations that he or she finds increasingly more fearful" (O'Leary and Wilson, 1975, p. 482).

Emotionality - This term refers to "physiological and affective arousal" (Morris and others, 1978, p. 590).

Math anxiety - This anxiety "involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson and Suinn, 1972, p. 551).

Negative or poor
Math self-concept - This involves "low self-esteem and feelings of incompetence which are manifested as self-deprecating remarks and a perpetual lack of success in mathematics" (Gourgey, 1985, p. 3).

Mathophobia - This term refers to "an irrational and impeditive dread of mathematics" (Resek and Rupley, 1980, p. 423).

Reification - This involves "attributing to a test score a physical meaning" (Beckwith, 1983, p. 158).

Relaxation training - This technique "involves a series of procedures in which subjects are given practice in tensing and relaxing various muscle groups" (Byrne, 1974, p. 215).

Self-instructional training - "A therapy method in which the client is taught to recognize and eliminate irrational thoughts and substitute more rational, constructive thoughts or covert, self-statements" (O'Leary and Wilson, 1975, p. 490.).

Worry - This is a "cognitive concern about performance and its consequences" (Morris and others, 1978, p. 590).

ANNOTATIONS

THE NATURE OF MATH ANXIETY

Dreger, Ralph M. and Lewis R. Aiken. "The Identification of Number Anxiety in a College Population." Journal of Educational Psychology 48 (1956): 344-351.

The purpose of this study was to determine the nature of 'number anxiety.' College students (male and female) were administered an intelligence test and the Taylor Manifest Anxiety Scale including items pertaining to general anxiety as well as number anxiety. Number anxiety was found to be a construct distinct from general anxiety bearing no relationship to intelligence but correlating with low math grades.

Elliott, P. "Question: Is Math Anxiety a Figment of the Imagination? Answer: Never! (A neurological glimpse at mathematics anxiety.)" International Journal of Mathematics Education in Science and Technology 14.6 (1983): 777-788.

This paper discussed the physiological and psychological contributors to mathematics anxiety. The author contrasted the psychophysiological activities during creative thought and those during anxious stressful thoughts. Recommendations to educators were made for helping students to become more productive and comfortable in mathematics classes through activities that can be used before, during, and after mathematics classes.

Fulkerson, F., J. Galassi and M. Galassi. "Relation between Cognitions and Performance in Math Anxious Students: A Failure of Cognitive Theory?" Journal of Counseling Psychology 31.3 (1984): 376-382.

The purpose of this study was to investigate the thought processes used by high and low math anxious students in order to determine existing differences (if any) in those processes. Students were screened according to their scores on the Mathematics Anxiety Rating Scale (MARS; Richardson and Suinn, 1972), and then asked to think aloud as they solved mathematics problems. These thoughts were categorized into one of eleven categories ranging from very inhibitive (to the math process) to facilitative. This author stated that in contrast to previous findings in the math and test anxiety literature, cognitions were not found to vary significantly according to levels of mathematics anxiety in this study.

Morris, Larry W., O.S. Kellaway, and Donna H. Smith. "Mathematics Anxiety Rating Scale: Predicting Anxiety Experiences and Academic Performance in Two Groups of Students." Journal of Educational Psychology 70.4 (1978): 589-594.

These researchers investigated the hypothesis that math anxiety is composed of two distinct components: worry and emotionality. They also studied the degree to which the Mathematics Anxiety Rating Scale (MARS) could predict these two components.

Mathematics and psychology college students were given the MARS within the first two weeks of the semester, and a worry-emotionality questionnaire immediately preceding their first exam. The MARS was not only found to be a valid predictor of the anxiety response, but also to correlate highly (and positively) with the levels of worry and emotionality. The component having the greatest effect on test performance was worry.

Rounds, James B., and Darwin D. Hendel. "Measurement and Dimensionality of Mathematics Anxiety." Journal of Counseling Psychology 27.2 (1980): 138-149.

These researchers studied the dimensionality of math anxiety. Female college students enrolled in a treatment program for math anxiety were given the Mathematics Anxiety Rating Scale (MARS), and the Suinn Test Anxiety Behavior Scale (STABS), along with other affective scales and an arithmetic test.

Two constructs were identified by the MARS: math test anxiety and a more general numerical anxiety (i.e. dealing with numbers in a non-evaluative setting). Math Anxiety was found to be an anxiety that is affected by the setting.

CAUSES AND CORRELATES OF MATH ANXIETY

Beckwith, Jon. "Gender and Math Performance: Does Biology Have Implications for Educational Policy?" Journal of Education 165 (1983): 158-174.

This author discussed the fallacies of using biological reasons exclusively in understanding sex differences in math achievement and anxiety. The following problems with using this explanation were discussed: 1) biological processes are given credit for differences that appear to exist due to societal differences; 2) the assumption is made that if differences exist due to biological states they cannot be altered (the author gave examples to demonstrate this to be a false assumption); 3) reification is used; and 4) none of these hypotheses have been proved.

Benbow, C. P., and Julian C. Stanley. "Sex Differences in Mathematical Ability: Fact or Artifact?" Science 210 (1980): 1262-1264.

This study examined sex differences in math aptitude while controlling for formal educational background. Jr. High and high school students were administered the verbal and math sections of the Scholastic Apitude Test (SAT).

Results demonstrated that males performed significantly better in all areas. The differences were significant as early as seventh grade, and increased when higher levels of reasoning were required.

Betz, N. E. "Prevalence, Distribution, and Correlates of Math Anxiety in College Students." Journal of Counseling Psychology 25.5 (1978): 441-448.

This study investigated the prevalence of math anxiety in a college population and the relationship between math anxiety and other relevant variables (i.e. sex, age, and other anxieties). College students were drawn from either a low level math course, and upper level math course, or an introductory psychology class. Scores on the Mathematics Anxiety Scale (MAS), two other anxiety inventories, and an achievement test were used in addition to background data.

It was found that the lower the level of mathematics course the student was enrolled in, and the greater the amount of time that had passed since the student had last taken a math class, the greater the math anxiety. Females were found to have greater levels of this anxiety in the psychology and low level math class.

Brush, L. R. "A Validation Study of the Mathematics Anxiety Rating Scale (MARS)." Educational and Psychological Measurement 38 (1978): 485-491.

This study investigated the relationship between math anxiety and math background, test anxiety, and math attitude. One group of male and female college students was administered the MARS in addition to items pertaining to their math background and their attitude toward math. A second group took the MARS and the Suinn Test Anxiety Behavior Scale (STABS).

Levels of math anxiety were found to correlate positively with a bad attitude toward math and test anxiety. MARS scores correlated negatively with years of high school math taken and grades earned in high school math courses.

Clarkson, P. C., and G. C. Leder. "Causal Attributions for Success and Failure in Mathematics: A Cross Cultural Perspective." Educational Studies in Mathematics 15 (1984): 413-422.

This study examined the attributional patterns of high and low math achievers in two countries. Tenth grade male and female students in Papua New Guinea and Australia were administered the Mathematics Attribution Scale (MAS), and two math achievement tests. Results indicated that low math achievers tended to attribute success to the task (instead of ability), and were more likely to attribute failure to the environment.

Dew, K. M., J. P. Galassi, and M. D. Galassi. "Math Anxiety: Relation With Situational Test Anxiety, Performance, Physiological Arousal, and Math Avoidance Behavior." Journal of Counseling Psychology 31.4 (1984): 580-583.

The purpose of this research was to study the prevalence of math anxiety, the relationship between math and test anxiety (specifically studying the worry and emotionality components of test anxiety), and the degree to which math anxiety scales are related to each other. The mathematics Anxiety Rating Scale (MARS) was administered to college students along with three other anxiety inventories.

Both males and females demonstrated levels of math anxiety with little variation in scores due to sex difference. Math anxiety was found to be distinct from but related to test anxiety. The MARS demonstrated the greatest reliability and internal consistency among the scales used.

Fennema, Elizabeth, and Julia Sherman. "Sex-Related Differences in Mathematics Achievement, Spatial Visualization and Affective Factors." American Educational Research Journal 14.1 (1977): 51-71.

The purpose of this study was to research sex differences in math achievement, attitudes, and background. Background information was gathered in addition to the administering of an achievement test, and a scale to measure affective variables (including two measures of math anxiety).

Two of the four high schools studied yielded results that revealed significantly higher achievement from males than from females. However when the variation due to the affective variables was controlled, no differences in achievement were apparent. Societal influence was hypothesized as a significant factor.

Fennema, Elizabeth, and Julia Sherman. "Sex Related Differences in Mathematics Achievement and Related Factors: A Further Study." Journal for Research in Mathematics Education 9 (1978): 189-203.

This study examined sex-related differences in math achievement, affective measures and cognitive variables. Tests of achievement, spatial relations ability and attitude were administered to students from different high schools (included here were measures sensitive to levels of math anxiety). Sex differences were found to be dependent on the high school; no universal differences were found. It was suggested that the sex differences found in two of the schools were due to societal influence.

Fennema, Elizabeth, and L. A. Tartre. "The Use of Spatial Visualization in Math by Girls and Boys." Journal For Research in Mathematics Education 16 (1985): 184-206.

This longitudinal study investigated the relationship between spatial visualization skills and math achievement in male and female students. Sixth grade students were given the Space Relations portion of the Differential Aptitude Test, the Verbal Skills Test, and the Mathematics Basic Concepts Test. This inventory took place during the students' sixth, seventh, and eighth grade years. Results revealed that students with low spatial visual skills did not differ in their ability to solve problems with those of greater ability in that area.

Frary, Robert B, and Jeanne L. Ling. "A Factor-Analytic Study of Mathematics Anxiety." Educational and Psychological Measurement 43 (1983): 985-993.

The purpose of this study was to determine the relationships between measures of math attitude (whose scales included measures of math anxiety), personality measures, math background, and math achievement. Twenty-one personality scales, five math attitude scales, and questions regarding math background were administered to over 400 college students.

Results demonstrated that math anxiety was significantly related to students' attitude toward math, which in turn correlated with low math achievement and avoidance of math in high school. No relationship between math anxiety and personality was determined. This researcher discussed the interrelationships between math anxiety, math attitude, math achievement and math avoidance.

Gourgey, Annette F. "The Relationship of Misconceptions About Math and Mathematical Self-Concept to Math Anxiety and Statistical Performance." Resources in Education, 20:7, July 1985. ED 254 417.

This study investigated the effects of misconceptions about math and math self-concept on math anxiety and achievement. Male and female college students were administered the Beliefs About Mathematics Scale, the Mathematical Self-Concept Scale, the Mathematics Anxiety Rating Scale, and an achievement test. Scores from the midterm exam were also used to measure achievement.

Results revealed that a significant portion of math anxiety involves a low math self-concept. The author hypothesized that personal fear of failure was involved.

Hendel, Darwin D. "Experiential and Affective Correlates of Math Anxiety in Adult Women." Psychology of Women Quarterly 5.2 (1980):219-230.

The purpose of this study was to determine some of the correlates of math anxiety. Female college students completed five anxiety scales (including the Mathematics Anxiety Rating Scale), a background questionnaire and an arithmetic test.

High correlations were found between math and test anxiety. Levels of math anxiety and high school math preparation were the best predictors of math performance in college.

Hilton, Thomas T., and Gosta W. Berglund. "Sex Differences in Mathematics Achievement--A Longitudinal Study." The Journal of Educational Research 67.5 (1974): 231-237.

This study investigated sex differences in math achievement and math interest, and the relationship between math interest and achievement. This was a longitudinal study whereby students were administered the Sequential Test of Educational Progress (STEP) and the School and College Ability Test (SCAT) in the fifth, seventh, ninth and eleventh grades. Information regarding math background and interest was collected at every interval (except fifth grade) as well.

Sex differences in achievement were revealed and significant beginning at grade seven and increasing through to the eleventh grade. Males demonstrated higher levels of interest, and interest level was found to vary with level of achievement.

Pedro, Joan D., Patricia Wolleat, Elizabeth Fennema, and Ann Becker. "Election of High School Mathematics by Females and Males: Attributions and Attitudes." American Educational Research Journal 18.2 (1981): 207-218.

This study researched variables believed to affect students' choices to take elective math courses. A battery of inventories and tests was given to determine the attitudinal and affective variables involved (including perceived usefulness of math and math anxiety). Achievement was measured by The Cooperative Mathematics Test.

Perceived usefulness of math demonstrated the greatest relationship to choice of taking math courses. High math anxious females reported failure to be due to a lack of ability.

Peterson, K., G. Burton, and Dale Baker. "Geometry Students' Role-Specific Self-Concept: Success, Teacher, and Sex Differences." Journal of Educational Research 77.2 (1983): 122-126.

This researcher investigated the effects of previous success in math (along with other variables) on students' math self-concept. Ninth and tenth grade geometry students were administered inventories to gather self-concept data. Level of success was based upon the grade received in the class.

Both success and teacher had a significant effect on how the students felt about themselves as math students. Contrary to other researchers' findings, no sex difference was found.

Resnick, H., J. Viehe, and S. Segal. "Is Math Anxiety a Local Phenomenon? A Study of Prevalence and Dimensionality." Journal of Counseling Psychology 29.1 (1982): 39-47.

The purpose of this research was to study the prevalence and dimensionality of mathematics anxiety among college freshmen at a university in New York. One thousand forty-five students completed the Mathematics Anxiety Rating Scale (MARS; Suinn, 1972), and the Strong-Campbell Interest Inventory (SCII). Information was also gathered from the students' mathematics and verbal scores on the Scholastic Aptitude Test (SAT), along with previous mathematics grades. It was found that these students had strong mathematics backgrounds (three or four years in high school), and significantly low levels of mathematics anxiety.

Sells, Lucy W. "High School Math as the Critical Filter in the Job Market." Resources in Education, 16:10, May 1981. ED 080 351.

This research embodied two studies. First, a study of sex differences in math training on the high school level was conducted. The second study examined the relationships between social support (from peers, parents and teachers) and level of math preparation in high school and between social support and math performance.

Results indicated that significantly more males (57) than females (8) took four years of high school math. Social support was found to play a significant role toward both the amount of math training and math performance.

Sherman, Julia. "Mathematics Spatial Visualization, and Related Factors: Changes in Girls and Boys, Grades 8-11." Journal of Educational Psychology 72.4 (1980): 476-482.

This study attempted to determine the relationship of differing spatial visualization backgrounds, sex and attitude to math achievement. Students were given the Fennema Sherman Mathematics Attitude Scales, a portion of the Differential Aptitude Test, and a math skills test in grade eight, and were tested again in the eleventh grade.

No sex difference in achievement occured in grade eight, but was present (and significant) in the eleventh grade. Because the sex difference in performance varied with the attitudes measured (i.e. positive attitude varied with increased performance), it was hypothesized that the difference in performance could be due to attitudinal factors. No sex differences in spatial visualization ability were revealed.

Sherman, Julia. "Factors Predicting Girls' and Boys' Enrollment in College Preparatory Mathematics." Psychology of Women Quarterly 7.3 (1983): 272-281.

This study attempted to identify factors at the eighth grade level that affected whether or not students elect to take math courses in high school. Eighth grade students were given the Mathematics Concepts Test, the Cognitive Abilities Test, an aptitude test, and the Fennema-Sherman Mathematics Attitude Scales (which include measures of math anxiety).

Results indicated significant differences in math enrollment for all variables. Students who took math all through high school had high scores on all variables tested in the eighth grade.

Sherman, Julia, and Elizabeth Fennema. "The Study of Mathematics by High School Girls and Boys: Related Variables." American Educational Research Journal 14.2 (1977): 159-168.

This study investigated the degree to which attitudes and feelings toward math affect decisions to take elective math courses. High School students were administered the Differential Aptitude Test, and the Fennema-Sherman Mathematics Attitude Scales. Information was also gathered regarding plans to take more math courses. Each of the affective variables was found to relate significantly to the decision to take (or not take) more math. When cognitive and affective variables were controlled, no sex differences were found in achievement (otherwise, there was a difference).

Stones, Ivan, Milton Beckman, and Larry Stephens. "Factors Influencing Attitudes Toward Mathematics in Pre-Calculus College Students." School Science and Mathematics 83.5 (1983): 430-435.

This researcher investigated the relationship between high school math background and math attitude. College students enrolled in a pre-calculus course took the Revised Math Attitude Scale (by Aiken and Dreger), reported on their high school math background, and their status as college students (i.e., freshmen, sophomores, etc.).

Results indicated that students with a strong math background from high school had significantly better attitudes toward math. Also, the later in the college career the student was, the worse the math attitude.

Wolleat, P. L., Ann Becher, J. D. Pedro, and Elizabeth Fennema. "Sex Differences in High School Students' Causal Attributions of Performance in Mathematics." Journal for Research in Mathematics Education 11 (1980): 356-366.

This research studied the relationships between sex, attributional pattern, and math achievement. High school students were administered the Mathematics Attributional Scale, and an achievement test. Results indicated a significant sex difference in attributional styles. While males tended to attribute success to ability, (a stable factor) females tended to attribute success to effort (an unstable factor). Females were also more likely than males to attribute failure to lack of ability.

TREATMENTS OF MATH ANXIETY

Bander, Ricki S., Richard K. Russell, and Kathy P. Zamostny. "A Comparison of Cue-Controlled Relaxation and Study Skills Counseling in the Treatment of Mathematics Anxiety." Journal of Educational Psychology 74.1 (1982): 96-103.

The purpose of this study was to determine the effectiveness of four interventions on math anxiety. College students were tested for levels of mathematics anxiety, test anxiety, math achievement and other anxieties. The four interventions included no treatment, cue-controlled relaxation training, Math Study Skills counseling, and a combination of relaxation and study skills instruction. Pre and post testing revealed cue-controlled relaxation to be the most effective intervention for both decreasing math anxiety and improving performance.

Clute, Pamela S. "Mathematics Anxiety, Instructional Method, and Achievement in a Survey Course in College Mathematics." Journal for Research in Mathematics Education 15.1 (1984): 50-58.

The purpose of this study was to compare the effects of two different instructional methods on math achievement and math anxiety. Female and male college students were assigned either to a course taught by the lecture approach (direct method) or the guided question approach (discovery method). The Mathematics Anxiety Rating Scale (MARS) and achievement tests were administered to gather data on anxiety and achievement levels. High math anxious students performed significantly better in the lecture setting as opposed to the discovery setting, while low anxious students performed best in the discovery method course.

DeBronac-Meade, Marie Louise. "Reduction of Mathematics Anxiety: A Cognitive Behavior Modification Approach." Paper presented at the annual meeting of the American Educational Research Association (New York, NY, March 19-23, 1982).

This research investigated the effectiveness of a cognitive behavior modification program on math anxiety. College students that reported problems with math anxiety were given the Mathematics Anxiety Rating Scale (MARS) and a family background questionnaire. The treatment program included education on self-statements, thought monitoring, relaxation and desensitization. Pre and post testing revealed a significant decrease in math anxiety for the treatment group.

Fennema, Elizabeth, Patricia Wolleat, Joan Pedro, and Ann Becher. "Increasing Women's Participation in Mathematics: An Intervention Study." Journal for Research in Mathematics Education 12.1 (1981): 3-14.

This study examined the effectiveness of a program whose purpose was to encourage females to take more elective math courses as preparation toward entering more math related vocations. Groups of females from three high schools were randomly assigned to control or experimental groups. The treatment was a workshop (one class period) which consisted of watching a videotape, followed by a discussion. The videotape included vignettes which provided information about the usefulness of math, sex differences in math education and suggestions for improvement. Data collected before and one month after treatment revealed that subjects in the treatment group increased their preference for math, perceived usefulness of math, and signed up for more math courses than the no treatment group.

Genshaft, Judy. "The Use of Cognitive Behavior Therapy for Reducing Math Anxiety." School Psychology Review 11 (1982): 32-34.

This research investigated the effectiveness of self-instruction training on reducing math anxiety. Seventh grade female subjects were assigned to one of three groups: a control group; a tutored group; or a group given self-instruction training in addition to tutoring. The self-instruction included training on how to not be self-critical of their actions and how to write down and examine statements that you make to yourself so that you can change them if necessary. All treatment groups were in effect for eight weeks. The Stanford Diagnostic Math Test was used to measure changes in achievement.

Pre and post testing indicated that the self-instruction group was the only group to significantly increase performance on computations. (All three of the groups improved on the application section suggesting a weakness in the study.)

Genshaft, Judy L. and Michael L. Hirt. "The Effectiveness of Self-Instructional Training to Enhance Math Achievement in Women." Cognitive Therapy and Research 4.1 (1980): 91-97.

This study investigated the effectiveness of a treatment that involved tutoring and self-instruction training. Seventh grade females were determined math anxious if their reading was above grade level and math was below grade level on the Stanford Achievement Test.

One group was administered two tutoring sessions, a second group was given tutoring and self-instruction training; and a third group was a control group. Pre and post testing was done on math performance, attitude, and course preference. The second group was found to have increased preference for math, math attitude and performance.

Hendel, D., and S. Davis. "Effectiveness of an Intervention Strategy for Reducing Mathematics Anxiety." Journal of Counseling Psychology 25.5 (1978): 429-434.

These researchers investigated the effectiveness of three components of a mathematics anxiety treatment program for adult women returning to college. A diagnostic clinic for determining math skills and levels of mathematics anxiety, special courses geared toward reducing anxiety in the students, and a support group for math anxious students were the three interventions used. Results indicated that the special math class in addition to the support group provided the greatest decrease in math anxiety. No between-group comparisons were reported.

Howard, Bessie C. "Mathematics in Content Areas, MICA. A Teacher Training Approach." Paper presented at annual conference of the Association of Teacher Educators (Phoenix, AZ. Feb. 14-17, 1982).

The purpose of this work was to address the problem of math anxiety and lowered math achievement through a program that prepared teachers to deal with these problems in an effective manner. This program, Mathematics in Content Areas (MICA), was aimed at getting math teachers to stress the purpose and usefulness of math by integrating other content areas into their classes. Similarly, other content teachers were directed on how to incorporate math with their disciplines. The program included models for elementary and secondary levels with specific lessons included.

Resek, Diane, and William Rupley. "Combating 'Mathophobia' with a Conceptual Approach Toward Mathematics." Educational Studies in Mathematics 11 (1980): 423-441.

This researcher described interventions that she used to combat mathophobia along with research conducted regarding problems encountered while running the program. The program, Math Without Fear, used seven approaches to make students more concept oriented in studying math: 1) guessing was encouraged (to get started on a problem), 2) concrete objects were used when possible to present a problem, 3) visual representations were used, 4) the playing of math games was incorporated, 5) students sometimes worked in small groups, 6) different levels of problems were used, and 7) emotional support was provided by instructors and other students.

Students were labeled math anxious according to their score on an attitude scale adapted from Aiken. Teacher reports revealed that math anxious students were receptive to change.

Shodahl, Susan A., and C. Diers. "Math Anxiety in College Students: Sources and Solutions." Community College Review 12 (1984): 32-36.

This author discussed a math anxiety treatment program along with its results. The program, Math Without Fear, included four components: 1) the students kept autobiographies; 2) the students kept journals; 3) a math anxiety text was used; and 4) instructors stressed the usefulness of math, the fun side of math through the use of special activities, games, and guest speakers. Pre and post testing (using the MARS, and a likert scale reflecting the perceived usefulness of math) revealed significant decreases in MARS scores, and positive reports regarding the usefulness of math.

SUMMARY

Dreger and Aiken performed one of the earliest research studies on math anxiety on record, and referred to the problem as 'number anxiety.' It was found that this problem was prevalent among students with low math grades, but not necessarily having a low intelligence. This anxiety was also found to be specific to situations requiring numerical computations, and was unrelated to levels of general anxiety. Much research has been conducted since that time to determine the nature of math anxiety. Rounds and Hendel found that the Mathematics Anxiety Rating Scale (MARS), which measures levels of math anxiety, actually identified two components of the problem. The first had to do with being anxious when working with numbers in general nonevaluative settings; the second was an anxiety specific to the taking of math tests. In conjunction with this, Morris and Kellaway found that students with high levels of math anxiety tended to experience significant levels of worry and emotionality while taking math tests which in turn have been found to have a signifcant (and deleterious) effect on performance.

Little empirical research has been done to answer the question of whether or not there is an internal, physiological basis for the difference in response between the math anxious and nonanxious student. However, Elliott discussed this issue and pointed to the psychophysiological differences between nonstressed, creative thought and anxious, stressed mental processes.

This researcher described the inhibitive effect stress has on cognitive processes versus the facilitative effect of a relaxed state on thought. Fulkerson mentioned other researchers who confirmed this relationship between the affective state and cognition. However, when she looked specifically at the cognitions of anxious and nonanxious students, no significant differences were found.

Math anxiety has been found to have many varied correlates. Frary and Ling pointed to the complexity of the problem when they reported the apparent circular nature of this anxiety whereby math anxiety was found to affect math attitude which hindered achievement which promoted math avoidance which in turn exacerbated levels of math anxiety.

While Sherman (1980) confirmed Frary's finding that math attitude and achievement co-vary, Betz confirmed the relationship between math anxiety and math avoidance in his study. Similarly, Sherman and Fennema (1977) found that all affective variables studied (including measures of math anxiety and attitude) correlated with student's choices to take elective math courses. In the same vein Stones, Brush, and Resnick found that a strong math background led to positive attitudes in mathematics and the MARS scores correlated highly (and negatively) with high school math background and grades. Further, Sherman (1983) found that the differences in attitude and cognitions that affected math

avoidance in high school could be detected as early as the eighth grade. Interestingly, when Pedro and others studied the various components of math anxiety and attitude that related to math avoidance, they found that the single most powerful factor was the perceived usefulness of math on the part of the student.

Test anxiety has been found to be another correlate of math anxiety. Dew, Galassi and Galassi, Hendel, and Brush all found strong (and positive) correlations between test and math anxiety. In this regard, it is interesting to note that both math anxiety and test anxiety have been found to have components of worry and emotionality (Dew, Galassi, and Galassi; Morris and Kellaway).

Low math self-concept was found to be another variable related to math anxiety. Gourgey found that students revealing high levels of this anxiety demonstrated that a significant factor involved was a low math self-concept. Further studying this issue, Peterson, Burton, and Baker found that this specific self-concept was largely due to the teacher, and level of success experienced in the class.

Finally, Fennama, Sherman and Betz (1977, 1978), have studied sex as a correlate of math anxiety and/or achievement. Fennema and others (1977) found significant differences in measures of math anxiety and achievement between male and female students (i.e., in general, where males revealed lower levels of math anxiety than females, they also achieved better in math). Similarly, Hilton found sex differences in math achievement and

interest with males achieving significantly higher than females beginning in the seventh grade and continuing (and increasing) through the eleventh grade. Furthermore, Benbow also found males to outperform females in all areas of math beginning with seventh grade and continuing through high school. These results were found even when educational background was controlled.

In an attempt to understand why the sex differences in achievement, anxiety and attitude existed, Fennema and others (1977, 1978) controlled the affective variables (i.e., perceived usefulness of math, math anxiety, etc.) in their study and found that with these measures controlled the differences in achievement diminished. As a result, Fennema suggested socio-cultural factors as being responsible for some of the differences in achievement (1977:69). Beckwith agreed with this notion and further discussed the fallacies of attributing discrepancies in achievement to biological differences (between the sexes). Further, Sells found that not only did males receive greater peer and parental support in taking math classes than did females, but this support was found to have a strong and positive effect on their choice to take math classes as well as on their performance.

To further try to understand the sex differences in achievement, Fennema and Tartre (1985) and Sherman (1980) studied sex differences in spatial relations ability. However, in both studies no relationship between spatial relations ability and

achievement was determined.

Finally, attributional patterns have been studied as a possible source of sex differences. Wolleat found that while males tend to attribute success to ability, females attribute success to the ~~task~~ effort. Furthermore, females were more likely to credit failure to lack of ability than males. Pedro and others confirmed this finding when they studied the problem among high math anxious females. Clarkson performed a similar study in a different cultural setting (New Guinea and Australia as opposed to the United States) and also found that low math achievers did not attribute success to ability.

Several approaches to the treatment of math anxiety have been developed and researched. One method involved the application of behavioral interventions in a group setting. Bander found cue-controlled relaxation training to be effective in both decreasing math anxiety and increasing math performance. Genshaft (1980, 1982) used self-instruction which improved computational performance; and further utilized self-instruction with tutoring which led to increased preference for math, improved math attitude and increased performance. DeBronac-Meade combined relaxation techniques and self-instruction along with thought monitoring and desensitization and found significant decreases in math anxiety as a result.

Other interventions were more academically focused in which

changes in instructional style were made. Shodahl, in the Math Without Fear program, utilized journals, a math anxiety text, and instructors sensitive and responsive to the needs of math anxious students. This program had a significant effect on anxiety levels as well as on student's perceived usefulness of math. Hendel and Davis also used special teachers along with a support group for math anxious students and saw significant decreases in MARS scores as well. Similarly, Resek incorporated instructor support in her approach along with the use of guessing, group work, visual aids and varying levels of math problems. While no research was conducted for this combination of strategies, instructors reported that the math anxious students were receptive to change. While Clute did not incorporate special instructors, she did compare two instructional methods and found that math anxious students performed significantly better in a lecture setting than in a discovery approach to learning.

Finally, two of the interventions studied focused on teaching students the usefulness and applicability of math. Howard's program, Mathematics in Content Areas (MICA), did this by incorporating other subjects into math class and vice versa. Fennema, Wolleat and Pedro (1981) did this by presenting a videotape which dealt with the usefulness of math along with other issues that have been found to affect math avoidance and anxiety such as sex stereotyping. While no follow up studies on

the MICA program have been reported, Fennema found that more members of their treatment group enrolled in elective math courses than members of the control group.

CONCLUSION

The material reviewed above has on the one hand revealed math anxiety as a straight forward concept involving a person's negative affect with regard to math topics which affects math performance and choices to study math. Yet, on the other hand, the actual existence of the problem in students has been demonstrated here to be a complex phenomenon involving such factors as societal influences, math self-concept, evaluative stress, and attributional patterns. The multi-faceted nature of the problem is further confirmed by the fact that interventions ranging from desensitization and self-instruction to simple instructional changes have been found to be effective. Due to the prevalence and complexity of this anxiety, educators need to be aware of the different aspects of the problem and be prepared to meet the varied needs of math anxious students.

RECOMMENDATIONS

It is recommended that:

1. Math instructors be made aware of this specific anxiety so that they can develop a sensitivity to the students with the problem.
2. Educators become familiar with the various instruments available that detect math anxiety so that they can determine which students have the problem.
3. Math classes include emphasis on the relevance of the topics being taught.
4. Teachers work to integrate other disciplines with math.
5. School systems either make services such as math tutoring, support groups, self-instruction, and relaxation training available to students, or know where to refer students for such training.
6. Educators evaluate their teaching methods to check for any sex stereotyping that they may be incorporating into their classrooms.
7. Teachers evaluate their methods to ensure that they are providing instruction that is helpful to the math anxious as well as the nonanxious student.
8. Further research be done to clarify the relationship between the various correlates of math anxiety so that the problem can be better understood and handled.

APPENDIX

One instrument, the Mathematics Anxiety Rating Scale (MARS) was used so often throughout this study that I have provided annotations to confirm its validity, test-retest reliability, and internal consistency reliability Additional data was also included on the Mathematics Anxiety Scale (MAS), and the Mathematics Attitude Scale (MAS).

Dew, Kathleen, John Galassi, and Merna Galassi. "Mathematics Anxiety: Some Basic Issues." Journal of Counseling Psychology 30.3 (1983): 443-446.

The purpose of this study was to examine the Mathematics Anxiety Rating Scale (MARS), and the Mathematics Anxiety Scale (MAS), and the relationship between mathematics anxiety and its correlates. Following a screening for levels of math anxiety, college students were administered the MAS, the MARS, the Anxiety Toward Mathematics Scale and math problems.

Results indicated significant correlations between the anxiety scales. The MAS and MARS were both found to have acceptable internal consistency and test-retest reliability.

Richardson, Frank C., and Richard M. Suinn. "The Mathematics Anxiety Rating Scale: Psychometric Data." Journal of Counseling Psychology 19.6 (1972): 551-554.

The purpose of this study was to provide normative, reliability and validity data on the Mathematics Anxiety Rating Scale (MARS). Two groups of college students completed the MARS twice (seven weeks apart) to obtain reliability data. Validity data was obtained by: 1) having three separate groups of students retake the MARS after participation in a treatment group; and 2) having a group of students complete the math section of the Differential Aptitude Test (DAT) after completing the MARS. The MARS was found to have high test-retest reliability (.85), as well as internal consistency reliability (.97). MARS scores decreased significantly after treatment, and correlated negatively (and to a significant degree) with performance on the DAT.

Rounds, James B., and Darwin D. Hendel. "Mathematics Anxiety and Attitudes Toward Mathematics." Measurement and Evaluation in Guidance 13.2 (1980): 83-89.

This body of research studied the construct, math anxiety, as it is measured by the Mathematics Anxiety Rating Scale (MARS), and the Mathematics Attitude Scale (MAS). Female college students enrolled in a math anxiety treatment program were administered the MARS, the MAS, and an arithmetic test. Results indicated that the MAS and the MARS measure different aspects of the anxiety, but both correlated strongly (and negatively) with scores on the arithmetic test.

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